INSTRUCTION MANUAL

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for
METER DEVIATION MONITOR

MODEL MDM-1

(For Use with FM-10 Series Mainframes)

Manual No. 500783-156 (Rev. D)

SINGER
INSTRUMENTATION

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FIGURE 1-1. METER DEVIATION MONITOR

SECTION I

GENERAL INFORMATION

1.1 PURPOSE

The meter deviation monitor (MDM-1) plug-in module is an auxilliary unit to the Singer FM-10 series frequency meter/signal generator (mainframe). The MDM-1 equips the mainframe to generate and measure frequency modulation up to 18 kHz peak deviation (calibrated) and to 60 kHz (uncalibrated).

1.2 MODES OF OPERATION

In the measuring mode, demodulated FM is displayed directly on a meter calibrated in kilohertz. In the FM generating modes, modulation is calibrated on the same meter and is controlled by a potentiometer on the front panel (INT MOD/AUDIO OUT control). An FM signal may be generated using the internal tone (1 kHz), an external tone, or a combination of the two. The 1 kHz modulation tone (controllable between 0 and 1 V rms) is also available at a front panel connector for modulation of external transmitters.

The peak deviation meter can be quickly switched from reading positive peak deviation to negative peak deviation and vice versa. This affords a convenient means of detecting distortion in a transmitter modulator.

Other means of monitoring modulation are provided: a loudspeaker presentation of the demodulated signal (in the mainframe) and a front panel signal output jack for connection to a distortion analyzer or oscilloscope.

The MDM-1 in conjunction with the mainframe provides a complete and self-contained FM communications field test package.

1.3 SPECIFICATIONS

Refer to table 1-1 for MDM-1 specifications.

> Note: The specifications given in table 1-1 apply in total only when MDM-1 is used in FM-10 mainframes, Serial No. 801 and above, or FM-10C mainframes, Serial No. 301 and above.

TABLE 1-1. MDM-1 SPECIFICATIONS

DEVIATION MONITOR FUNCTIONS	
Peak deviation ranges:	1.8 kHz for full scale deflection
	6.0 kHz for full scale deflection
	18 kHz for full scale deflection
Accuracy at 1 kHz modulation frequency:	100 Hz ±5% of full scale deflection
Accuracy from 50 Hz to 3 kHz modulation frequency:	100 Hz ±7% of full scale deflection
Sensitivity (with FM-10: 1 MHz to 500 MHz) -	
Operate:	6 mV rms ±3 dB (at MEASURE INPUT)
Overload:	60 mV rms ±3 dB (at MEASURE INPUT)
Sensitivity (with FM-10C: 1 MHz to 512 MHz) -	
Operate (RFM-10):	6 mV rms ±3 dB (at MEASURE INPUT)
Overload (RFM-10):	60 mV rms ±3 dB (at MEASURE INPUT)
Operate (RFM-10A):	20 uV rms to greater than 14 mV rms (at MEASURE INPUT)
Overload (RFM-10A)	20 dB ±3 dB above nominal operate level (at MEASURE INPUT)
Distortion analyzer output -	
Bandwidth:	< 50 Hz to > 3 kHz (3 dB referenced to 1 kHz)
Output level:	280 mV p-p ±10% at 5 kHz deviation. DC level of 4.5 V dc ±10%
Source impedance:	120 Ω ±20%.

TABLE 1-1. MDM-1 SPECIFICATIONS (Cont.)

FM MODULATOR FUNCTION	
Internal modulation -	
Frequency range:	1 kHz ±5%
Deviation Range:	0 to 18 kHz minimum (FM-10C)
	0 to 60 kHz minimum (FM-10)
Distortion (with FM-10C):	3% maximum at 18 kHz peak deviation
External modulation (FM-10C) -	
Frequency range:	300 Hz to 3 kHz (3 dB referenced to 400 Hz)
Deviation range:	0 to 18 kHz (minimum)
Input impedance:	600 Ω ±20%
Input sensitivity:	100 mV rms ±20% for 5 kHz deviation at 400 Hz
Distortion:	3% maximum at 1 kHz rate for 18 kHz peak dev
Note: For peak deviations up to 100 kHz and modulation frequencies as low as 50 Hz, the external VCO input on the rear of the FM-10C may be used (see FM-10C application note No. 19C).	
External modulation (FM-10) -	
Frequency range:	50 Hz to 3 kHz (3 dB referenced to 1 kHz)
Deviation range:	0 to 60 kHz minimum
Input impedance:	600 Ω ±20%
Input sensitivity:	500 mV rms ±20% for 5 kHz with V in narrowband
	500 mV rms ±20% for 50 kHz with V in wideband
Audio output (front panel) -	
Frequency:	1 kHz ±5%
Voltage:	Variable 0-1 V rms (minimum) into a 600 Ω load
Source impedance:	600 Ω ±20%
Distortion:	1% maximum

TABLE 1-1. MDM-1 SPECIFICATIONS (Cont.)

MISCELLANEOUS	
Auxiliary power output:	+9 V dc at 50 mA (maximum)
Operating temperature:	-5°C to +50°C (when installed in mainframe)
Weight:	2 1/2 lbs. nominal
Size:	6" x 6" x 12" approximately
Power:	9 V dc at 110 mA maximum (supplied by mainframe)

SECTION II

INSTALLATION

2.1 INSTALLATION PROCEDURE

To install MDM-1 in mainframe:

a. Remove blank plate covering plug-in aperture by turning the two screws one-quarter turn CCW.

b. Remove protective cover on connector at rear of aperture.

c. Insert MDM-1 until flush with front panel.

d. Turn locking pawl CW until plug-in is firmly locked.

SECTION III

OPERATING INSTRUCTIONS

3.1 INTRODUCTION

This section contains instructions for operating the MDM-1 plug-in module in conjunction with the mainframe. Refer to the mainframe operating manual for functions such as: power supply connections, RF output control, RF input setups, and beat note zeroing procedures.

3.2 CONTROLS AND INDICATORS

The function of all operating controls, indicators, and connectors on the MDM-1 are described in table 3-1.

3.3 OPERATING PROCEDURES

3.3.1 Measurement of Peak Deviation (FM-10)

a. Dial frequency controls to frequency of transmitter. Example: Transmitter frequency: 156.0359 MHz.

b. Offset FM-10 mainframe frequency by ±2 MHz. For above example: 154.0359 MHz or 158.0359 MHz.

c. Couple transmitter RF output to mainframe MEAS INPUT connector via antenna provided, or use RF cable input with an RFA-60 attenuator in the line. (See mainframe procedures.)

TABLE 3-1. CONTROLS AND INDICATORS

FIGURE 3-1 NUMBER	PANEL MARKING	TYPE	FUNCTION
1	PEAK DEVIATION KILOHERTZ	Meter	Has two functions controlled by meter switch (MTR): 1. Indicates limiter current 2. Indicates frequency deviation in kilohertz A red line on the scale labelled "LIM CUR" indicates minimum current necessary to obtain a deviation reading. The scale markings are in kHz.
2	INT MOD/ AUDIO OUT	Resistor, Variable	Has two functions controlled by the modulation switch (MOD): 1. Varies the frequency deviation from zero to 60 kHz maximum when the modulation switch is in the INT/ COMB (IN) position. 2. Varies the voltage of the 1kHz tone output from 0 to 1 V rms when the modulation switch is in the EXT (OUT) position.
3	MTR LIM IN DEV OUT	Switch, push-push	Control function of the PEAK DEVIATION meter. LIM (IN) position: Meter reads the limiter current. DEV (OUT) position: Meter reads the peak deviation in kHz.
4	DEV + IN	Switch push-push	Selects the positive or negative half waves of recovered modulation. Provides a means of checking the distortion of FM input signal. A difference in peak deviation meter readings in the +(IN) and -(OUT) positions indicates the presence of distortion.
5	MOD INT/COMB IN EXT OUT	Switch push-push	1. INT/COMB (IN) position: the internal 1kHz modulation tone, and any external tone, connected to the external modulation (EXT MOD) connector, frequency modulates the RF output. The level of the internal tone is controlled by the INT MOD/AUDIO OUT control.

TABLE 3-1. (Continued)

FIGURE 3-1 NUMBER	PANEL MARKING	TYPE	FUNCTION
5 (Cont.)			2. EXT (OUT) position: the internal 1 kHz tone is switched out and only an external tone modulates the RF output. In the OUT position, the 1 kHz internally generated tone is available at the AUDIO OUT (1 kHz, 600Ω) connector.
6	DEVIATION RANGE 1.8 kHz, 6 kHz, 18 kHz	Switches, Interlocked pushbutton	Select the calibrated deviation ranges of the meter. A lock-out mechanism prevents the operation of more than one pushbutton simultaneously.
7	AUDIO OUT	Connector, BNC	Provides 1 kHz output when modulation switch (MOD) is in the EXT (OUT) position. Output level is 0 to 1 V rms into 600Ω controlled by INT MOD/AUDIO OUT variable control.
8	SCOPE/ DIST ANAL	Connector, Phone jack	Provides demodulated signal output for an oscilloscope display or analysis by a distortion analyzer. +9 V dc at 50 mA maximum is also available at this connector.
9	EXT MOD	Connector, BNC	An external modulation tone may be applied to this connector. A modulation signal applied to this connector will modulate the mainframe when the modulation switch (MOD) is in both the INT/COMB (IN) position and in the EXT (OUT) position.
10	(Rear Panel Connector P1)	Connector, 16 pin	
	Pin #2		Chassis ground
	Pin #4		Cable Shield for Pin #12
	Pin #5		Same as SCOPE/DIST ANAL (Item 8)
	Pin #6		Cable Shield for Pin #14
	Pin #8		Cable Shield for Pin #16
	Pin #9		+9 V dc ±10% at 110 mA maximum (regulated)
	Pin #12		Audio signal from the internal 1 kHz oscillator or 50 Hz to 3 kHz from an external modulation source. Source impedance is 560Ω in the EXTERNAL MOD position and varies with the setting of the AUDIO OUT level control.

TABLE 3-1. (Cont.)

FIGURE 3-1 NUMBER	PANEL MARKING	TYPE	FUNCTION
10 (Cont.)	Pin #12 (Cont.)		Output level is greater than 600 mVrms from an internal modulation source with audio output level at maximum and a 5.6 kΩ load.
	Pin #13		Cable Shield for Pin #5
	Pin #14		Recovered audio output to the audio amplifier in the mainframe. Should be greater than 40 mV rms into a 100Ω load for full scale deflection. 3 dB bandwidth should be greater than 50 Hz to 3 kHz. Output impedance is 10Ω maximum at 1 kHz with level proportional to peak deviation.
	Pin #16		2 MHz IF input from mainframe at a level of 2.5 mV rms ±3 dB with a load impedance of 100Ω ±20%.

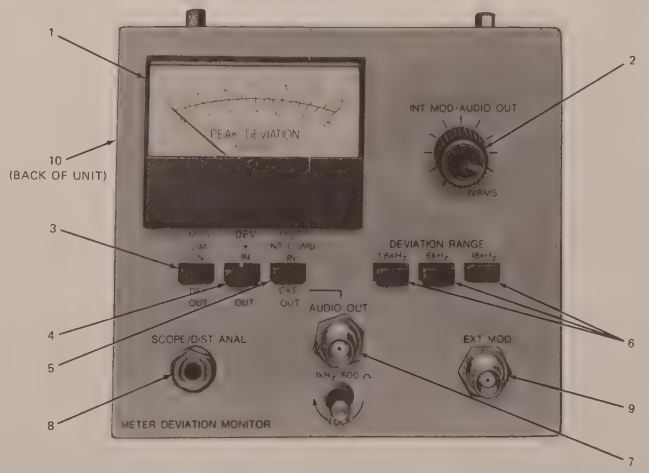

FIGURE 3-1. CONTROLS AND INDICATORS

d. Set MDM-1 switches as follows:

MTR	LIM (IN)

e. Set mainframe switches as follows:

AUDIO	MOD (OUT)
10 MHz	(OUT)

f. Key transmitter (do not modulate).

g. Increase coupling between transmitter and mainframe until limiter current reading on meter is between red line and full scale deflection.

h. Set MTR switch to DEV (OUT).

j. Modulate transmitter by voice or tone.

> Note: A 1 kHz tone, variable from 0-1 V rms is available from the AUDIO OUT connector. Refer to paragraph 3.4.5 for the setup.

k. Select appropriate DEVIATION RANGE switch for an on-scale meter reading.

l. Note deviation reading.

m. Alternately set DEV switch to +(IN) and - (OUT). If there is a noticeable difference in meter readings in + and - positions, there is a possibility of distortion in transmitter modulator.

n. Monitor modulation aurally by adjusting VOLUME control to desired listening level.

p. To investigate audio distortion further, connect an oscilloscope or distortion analyzer to SCOPE/DIST ANAL jack.

3.3.2 Measurement of Peak Deviation (FM-10C)

a. Dial frequency controls to frequency of transmitter. Example: Transmitter frequency: 156.0359 MHz.

b. Couple transmitter RF output to mainframe MEAS INPUT connector via antenna provided, or use RF cable input with an RFA-60 attenuator in the line. (See mainframe procedures.)

c. Set MDM-1 switches as follows:

MTR LIM (IN)

d. Key transmitter (do not modulate).

e. Increase coupling between transmitter and mainframe until limiter current reading on meter is between red line and full scale deflection.

f. Set MTR switch to DEV (OUT).

g. Modulate transmitter by voice or tone.

> Note: A 1 kHz tone, variable from 0-1 V rms is available from the AUDIO OUT connector. Refer to paragraph 3.4.6 for the setup.

h. Select appropriate DEVIATION RANGE switch for an on-scale meter reading.

j. Note peak deviation reading.

k. Alternately set DEV switch to + (IN) and - (OUT). If there is a noticeable difference in meter readings in the + and - positions, there is a possibility of distortion in transmitter modulator.

n. Monitor modulation aurally by adjusting VOLUME control to desired listening level.

p. To investigate audio distortion further, connect an oscilloscope or distortion analyzer to SCOPE/DIST ANAL jack.

3.3.3 Internal Frequency Modulation (FM-10)

Note: In order to modulate the frequency, the 0-1 kHz frequency control on the FM-10 must be set to a position other than OUT.

3.3.4 Narrowband (0-6 kHz) Peak Deviation (FM-10) Example: Modulate 273.939 MHz to 5 kHz deviation.

a. Set controls on FM-10 as follows:

Frequency controls	008.0V0
0-1 kHz control	0
10 MHz	(IN)
AUDIO	MOD (OUT)

b. Set controls on MDM-1 as follows:

DEVIATION RANGE	6 kHz
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

c. Rotate INT MOD/AUDIO OUT control until meter indicates 5 kHz.

d. Set the 10 MHz switch to OUT.

e. Set FM-10 mainframe frequency controls to 273.9V0 MHz.

f. Set 0-1 kHz frequency control to 39.

g. Mainframe/MDM-1 is generating 5 kHz peak deviation at 273.9390 MHz.

3.3.5 Wideband (6 kHz-18 kHz) Peak Deviation (FM-10) Example: Modulate 273.9398 MHz to 15 kHz.

a. Set controls on FM-10 as follows:

Frequency controls	008.V00
0-1 kHz control	0
10 MHz	(IN)
AUDIO	MOD (OUT)

b. Set controls on MDM-1 as follows:

DEVIATION RANGE	18 kHz
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

c. Rotate INT MOD/AUDIO OUT control until meter indicates 15 kHz.

d. Set the 10 MHz switch to OUT.

e. Set FM-10 mainframe frequency controls to 273.V00 MHz.

f. Set 0-1 kHz frequency control to 9.39.

g. Mainframe/MDM-1 is now generating 15 kHz peak deviation at 273.9398 MHz.

3.3.6 Wideband (18 kHz-60 kHz) Peak Deviation (FM-10) Example: Modulate 36.2471 MHz to 50 kHz peak deviation.

a. Set controls on FM-10 as follows:

Frequency controls	008.0V0
0-1 kHz control	0
10 MHz	(IN)
AUDIO	MOD (OUT)

b. Set MDM-1 controls as follows:

DEVIATION RANGE	6 kHz
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

c. Rotate INT MOD/AUDIO OUT control until meter indicates one tenth of desired peak deviation (5 kHz).

d. Set 10 MHz switch to OUT.

e. Set mainframe frequency controls to 36.V00 MHz.

f. Set 0-1 kHz frequency control to 2.47.

g. Mainframe/MDM-1 is now generating 50 kHz peak deviation at 36.2471 MHz.

> Note: In the example, the peak deviation of 5 kHz is set up with the 10 kHz frequency control in the V position. This is multiplied by 10 when the 100 kHz frequency control is set at V in step 3.3.6-e. The peak deviation thus becomes 50 kHz.

3.3.7 Internal Frequency Modulation (FM-10C)

3.3.8 Narrowband (0-6 kHz) Peak Deviation (FM-10C) Example: Modulate 273.939 MHz to 5 kHz peak deviation.

a. Set controls on the FM-10C as follows:

Frequency controls	273.9390
GENERATOR MODULATION	ON (IN)
MODE	GEN MOD CAL

b. Set MDM-1 controls as follows:

DEVIATION RANGE	6 kHz
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

c. Rotate INT MOD/AUDIO OUT control until meter indicates 5 kHz.

d. Set FM-10C mainframe MODE switch to GEN.

e. Mainframe/MDM-1 is generating 5 kHz peak deviation at 273.9390 MHz.

3.3.9 Wideband (6 kHz-18 kHz) Peak Deviation (FM-10C). Example: Modulate 273.9398 MHz to 15 kHz.

a. Set controls on FM-10C as follows:

Frequency controls	273.9398
GENERATOR MODULATION	ON (IN)
MODE	GEN MOD CAL

b. Set MDM-1 controls as follows:

DEVIATION RANGE	18 kHz
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

c. Rotate INT MOD/AUDIO OUT control until meter indicates 15 kHz.

d. Mainframe/MDM-1 is now generating 15 kHz peak deviation at 273.9398 MHz.

3.3.10 Wideband (18-60 kHz) Peak Deviation (FM-10C)

a. Set the FM-10C 0-100 Hz dial to 0.

b. Set the MDM-1 controls as follows:

DEV RANGE	AS required
MOD	EXT (OUT)
MTR	DEV (OUT)

c. Set appropriate decade switch to the V position. For peak deviations between 50 Hz and 500 Hz, use 1 kHz decade; and for peak deviations between 500 Hz and 5 kHz, use 10 kHz decade. For peak deviations greater than 5 kHz, use 100 kHz decade.

d. Set FM-10C, 0-100 Hz variable control to 0, not to OFF.

e. Set all decades except decade in V position to 0.

f. Set FM-10C MODE switch to GEN MOD CAL.

g. Connect AUDIO OUT jack to FM-10C rear panel ACC socket (signal to B and ground to H), and adjust INT MOD/AUDIO OUT control for desired peak deviation on MDM-1 meter.

h. Set all decade switches to the left of decade at V position to desired operating frequency and turn variable 0-100 Hz control to digit desired on decade which is in V position, i.e., if a signal at 151.53 MHz with a 1 kHz peak deviation is desired, set frequency dial to 1515V003.

Note: Decades to the right of a V are not active.

j. Set MODE switch to GEN and RF output level as appropriate. FM-10C is now generating an FM carrier.

3.3.11 Combined (0-18 kHz) Internal/External (Two-Tone) Modulation (FM-10)

a. Connect audio oscillator to EXT MOD connector of MDM-1.

b. Set audio oscillator to desired frequency and set to zero output.

c. Set controls on FM-10 as follows:

0-1 kHz control	0
10 MHz	(IN)
AUDIO	MOD (OUT)
Frequency controls	008.V000 MHz (Wideband modulation)
	008.0V00 MHz (Narrowband modulation)

d. Set MDM-1 controls as follows:

DEVIATION RANGE	As required
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

e. Rotate INT MOD/AUDIO OUT control until meter indicates desired deviation for internal 1 kHz tone.

f. Increase audio oscillator output until meter indicates total deviation desired for external tone plus internal tone.

g. Set 10 MHz switch to OUT.

h. Set mainframe frequency controls to desired carrier frequency. Example: 97.3527 MHz.

j. Set 10 kHz or 100 kHz frequency control to V position, as in step 3.4.1-c.

k. Set 0-1 kHz frequency control to appropriate setting: 3.527 for wideband or 5.27 for narrowband.

m. Mainframe/MDM-1 is now generating two-tone frequency modulation at desired carrier frequency.

3.3.12 Combined (0-18 kHz) Internal/External (Two-Tone) Modulation (FM-10C)

a. Connect audio oscillator to the EXT MOD connector.

b. Set external audio oscillator to desired frequency and set to zero output.

c. Set controls on mainframe as follows:

MODE	GEN MOD CAL
MEASURE MODE AUDIO OUTPUT	RECOVERED AUDIO (OUT)
GENERATOR MODULATION	ON (IN)

d. Set controls on MDM-1 as follows:

DEVIATION RANGE	As required
MOD	INT/COMB (IN)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW

e. Set mainframe frequency controls to desired carrier frequency.

f. Rotate INT MOD/AUDIO OUT control until meter indicates desired peak deviation.

g. Increase audio oscillator output until meter indicates total peak deviation desired for external tone plus internal tone.

h. Set MODE switch to GEN.

j. Mainframe/MDM-1 is now generating a two-tone FM carrier at frequency set on frequency controls.

3.3.13 External Frequency Modulation (FM-10)

a. Connect audio oscillator to EXT MOD connector.

b. Set audio oscillator to desired frequency and set to zero output.

c. Set controls on FM-10 as follows:

0-1 kHz control	0
10 MHz	(IN)
AUDIO	MOD (OUT)
Frequency controls	008.V000 MHz (Wideband modulation)
	008.0V00 MHz (Narrowband modulation)

d. Set controls on MDM-1 as follows:

DEVIATION RANGE	As required
MOD	EXT (OUT)
MTR	DEV (OUT)

e. Set MOD switch to EXT (OUT).

f. Increase audio oscillator output until meter indicates the desired peak deviation.

g. Set 10 MHz switch to OUT.

h. Set mainframe frequency controls to desired carrier frequency. Example: 97.3527 MHz.

j. Set 10 kHz or 100 kHz frequency control to V position as in step 3.4.3-c.

k. Set 0-1 kHz frequency control to appropriate setting: 3.527 for wideband or 5.27 for narrowband.

m. Mainframe/MDM-1 is now generating frequency modulation at desired carrier frequency.

3.3.14 External Frequency Modulation (FM-10C)

a. Set external audio oscillator to desired frequency and set to zero output

b. Set controls on mainframe as follows:

MODE	GEN MOD CAL
MEASURE MODE AUDIO OUTPUT	RECOVERED AUDIO (OUT)
GENERATOR MODULATION	ON (IN)

c. Set MDM-1 controls as follows:

MOD	EXT (OUT)
MTR	DEV (OUT)
INT MOD/AUDIO OUT	Fully CCW
DEVIATION RANGE	As required

d. Set mainframe frequency controls to desired carrier frequency.

e. Connect audio oscillator output to EXT MOD connector.

f. Increase audio oscillator output until meter indicates the peak deviation desired for external tone.

g. Set MOD switch to EXT (OUT).

h. Set MODE switch to GEN.

j. Mainframe/MDM-1 is now generating a frequency modulated carrier at frequency set on frequency controls.

3.3.15 Audio Test Tone Generation (FM-10)

Note: The 1 kHz modulation tone developed by the mainframe/MDM-1 is available at the AUDIO OUT connector only when the MOD switch is at the EXT (OUT) position for the testing of transmitters and repeaters.

a. Connect transmitter microphone input to AUDIO OUT connector.

b. Set MOD switch to EXT (OUT).

c. Set INT MOD/AUDIO OUT control to level desired (a maximum of 1 V rms into 600 Ω is available).

3.3.16 Audio Test Tone Generation (FM-10C)

Note: The 1kHz modulation tone developed by the mainframe/MDM-1 is available at the AUDIO OUT connector only when the MOD switch is at the EXT (OUT) position for testing of transmitters and repeaters.

a. Connect transmitter microphone input to AUDIO OUT connector.

b. Set MOD switch to EXT (OUT).

c. Set INT MOD/AUDIO OUT control to level desired (a maximum of 1 V rms into 600 Ω is available).

SECTION IV

THEORY OF OPERATION

4.1 INTRODUCTION

This section consists of the circuit description of the MDM-1 plug-in module. The information is presented to assist the user in the troubleshooting and maintenance of the unit. Refer to the detailed block diagram, figure 4-1; and the schematic diagram, figure 6-1.

4.2 THEORY OF OPERATION

4.2.1 GENERAL. The MDM-1 plug-in module derives its power supply and IF signal inputs via the rear connector, P1. The unit is energized whenever the mainframe is operating. A single printed circuit board assembly contains the three major sections of the MDM-1: Limiter current circuitry, deviation circuitry, and modulating circuitry.

4.2.2 LIMITER CURRENT CIRCUITRY

A 2 MHz active filter consisting of Q1, L1, L2, and L3 amplifies and filters the 2 MHz IF signal, which is derived by mixing the incoming signal with the synthesized FM-10 signal offset by 2 MHz (or with the synthesized FM-10C signal with no offset. Offset is programmed into the FM-10C so that 2 MHz offset is not required). The 3 dB bandwidth of the filter is approximately 50 kHz.

The amplified output of the 2 MHz active filter is applied to emitter follower, Q2, acting as a buffer amplifier.

The 2 MHz tuned amplifier, Q3 and L5, supplies the voltage doubler rectifier, CR7 and Q4, which acts as a signal threshold detector. The output of the threshold detector is a dc voltage proportional to the IF signal level which is fed to the MTR switch, S3.

With S3 in the LIM position, variable resistor, R40, is adjusted so that the meter indicates the minimum allowable 2 MHz input signal level required to achieve full limiting of the limiter-discriminator, U2. A red line on the meter scale indicates this level.

Meter protection is achieved by diodes CR8 and CR9. The Limiter, CR 1 thru CR6, is designed to allow 20 dB of dynamic range at the 2 MHz IF input.

4.2.3 DEVIATION CIRCUITRY

The amplified output of the active filter is also applied to the limiter-discriminator, U1 and L4. This is a quadrature-type discriminator containing a de-emphasis network, and its output is applied via the emitter follower, Q5, acting as a buffer amplifier to the front panel SCOPE/DIST ANAL connector, J1, and to the rear connector, P1-5, which is not used at the present time.

The discriminator output is also applied to the deviation range divider network, R16, R17, R18, and R19. The DEVIATION RANGE switch, S1, selects one of the three ranges: 1.8, 6, or 18 kHz, and applies the signal to the phase splitter, Q6.

Q6 is a field effect transistor with a high input impedance so that it will not load the deviation range divider network. The two identical outputs from Q6, 180° apart in

phase, are selected by the DEV switch, S2. This allows positive or negative-going peaks to be read on the front panel deviation meter. The signal selected by the DEV switch, S2, is applied to the recovered audio amplifier, Q7 and Q8.

Q7 is a field effect transistor with a high input impedance so that the drain of Q6 is not heavily loaded when the DEV switch, S2, is in the - position. The output of Q2 is applied to emitter follower, Q9.

The output of the buffer amplifier, Q9, is applied to the rear connector, P1-14. This supplied the mainframe audio amplifier with the recovered audio signal.

The output of Q8 also is applied to the peak detector, U2 and CR10. The output of the peak detector supplies a dc voltage proportional to the peak value of the recovered audio to the MTR switch, S3.

With the MTR switch, S3, in the DEV position, the meter indicates the peak deviation in kilohertz.

The meter is in series with the dc feedback path of U2. Calibration of the meter is accomplished by variable resistor, R47.

4.2.4 MODULATING CIRCUITRY

The internal modulator circuitry consists of an automatically levelled 1 kHz wein bridge oscillator. The basic wein bridge oscillator consists of Q10 and Q11 and is buffered by the emitter follower, Q12, and is automatically amplitude levelled by the field effect transistor, Q15.

Automatic levelling is achieved by sampling the output voltage of the emitter of Q12 and rectifying it by the voltage doubler rectifier, CR11 and CR12. The output of voltage doubler, CR11 and CR12, is a dc voltage proportional to the level of the 1 kHz output and varies the resistance between source and drain of the field effect transistor, Q15, which in turn varies the bias of Q10. Variable resistor, R58, is adjusted for the desired output level, and variable resistor, R56, is adjusted for the desired frequency (1 kHz).

With the MOD switch, S4, in the INT/COMB position, the INT MOD/AUDIO OUT control, R63, may be rotated to the desired peak deviation of the mainframe. MOD switch, S4, couples the internal 1 kHz oscillator to the mainframe via the rear panel connector, P1-12, for modulation purposes. With the MOD switch, S4, in this same position (INT/COMB), an external test tone frequency may simultaneously be injected into the mainframe via the EXT MOD front panel connector, J2.

With the MOD switch in the EXT position, an external test tone frequency may be applied to the EXT MOD front panel connector for modulating the mainframe with frequencies other than 1 kHz. In this switch position, the internal 1 kHz oscillator output is applied to the front panel AUDIO OUT connector, J3, for modulation of external transmitters via the audio driver amplifier, Q13 and Q14.

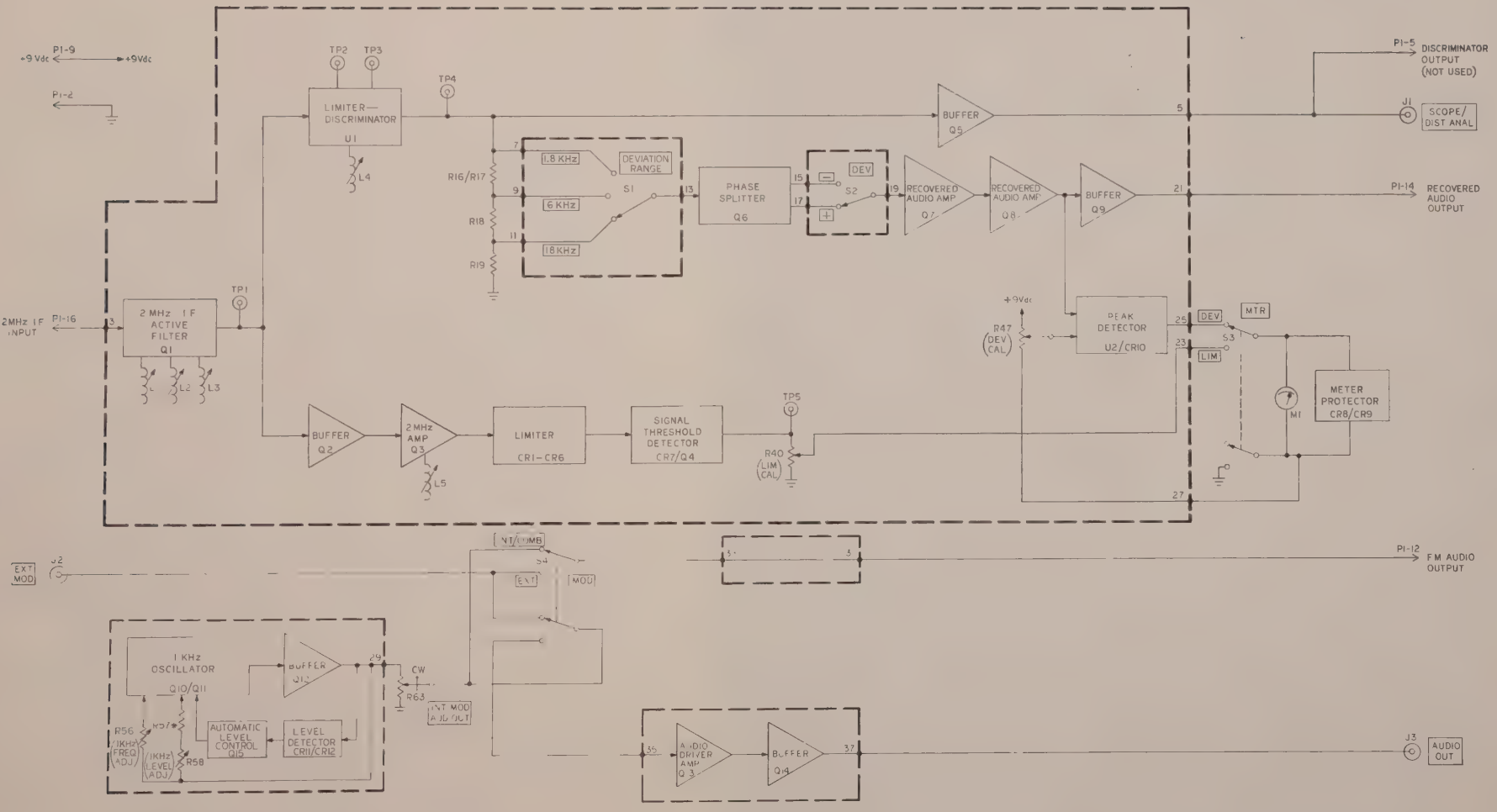

FIGURE 4-1. DETAILED BLOCK DIAGRAM, MODEL MDM-1

SECTION V

MAINTENANCE

5.1 INTRODUCTION

This section contains general maintenance, troubleshooting, and alignment information.

> NOTE: This section refers to use with the FM-10 mainframe in general. Where procedures deviate from FM-10C procedures, the necessary information is given in parentheses.

5.2 GENERAL MAINTENANCE INFORMATION

5.2.1 BASIC REQUIREMENTS. Each MDM-1 module is carefully checked at the factory, and no further internal adjustments are required prior to placing the equipment in operation. In the event of failure or malfunction, troubleshooting or adjustments should be attempted only if the proper test equipment is available, and only by qualified technicians.

5.2.2 TEST EQUIPMENT. The test equipment required for checkout, alignment, calibration, and troubleshooting is tabulated in Table 5-1. Minimum parameters are given to aid in the selection of the equivalent types.

5.3 MINIMUM PERFORMANCE CHECKOUT PROCEDURE

5.3.1 REMOVAL OF SHIELD. The shield is secured to the chassis by four screws. Remove these four screws and remove shield.

5.3.2 POWER REQUIREMENTS. All power required by MDM-1 is supplied by mainframe.

5.3.3 SENSITIVITY CHECK.

a. Install MDM-1 in mainframe and turn power switch on.

b. Set mainframe frequency switches to 150.000 MHz.

c. Connect signal source to mainframe MEASURE INPUT jack and set signal source for an output of 150 MHz at rated sensitivity of mainframe. (Set FM-10C MODE switch to MEAS.)

TABLE 5-1

TEST EQUIPMENT REQUIREMENTS

INSTRUMENT	MINIMUM PARAMETERS	RECOMMENDED MODEL
Audio Oscillator	Frequency range: 400 Hz-1 kHz Output level: 100-500 mV rms ±20% Output impedance: 600 Ω	Hewlett-Packard Model 200 CD
AC VTVM	Frequency response: 1 kHz to 2 MHz Voltage measurement: 120 mV-1.1 V rms	Hewlett-Packard Model 400 D
Signal Source	Frequency range: 150 MHz Output level: <6mV-> 60 mV rms Stability: > ±0.0004%/5min Levelling: ±1 dB Output impedance: 50 Ω	Singer Model FM2748
Oscilloscope	Frequency response: 10 MHz	Tektronix Model 651B with X10 probe
Distortion Analyzer	Capable of measuring distortion < 1% at 1 kHz with 1 V rms	Hewlett-Packard Model 331A
Frequency Counter	Frequency measurement: 1 kHz at 1 V rms input Input impedance: >10 kΩ	Hewlett-Packard Model 5245L
AC/DC Differential Voltmeter	DC Accuracy: ±0.01% AC Accuracy: ±0.3 %	Fluke Model 883A B

d. Tune signal source until mainframe indicates zero beat.

e. Set FM-10 only to 152.000 MHz.

f. Set MDM-1 MTR switch to LIM (IN) position.

g. MDM-1 meter should indicate "red line" with signal source output within the rated sensitivity range of the mainframe.

h. Modulate the signal source at a 1 kHz deviation rate.

j. Set MDM-1 MTR switch to DEV (OUT) position and DEVIATION RANGE switch to 6 kHz position.

k. Adjust modulation level on signal source for exactly 5 kHz on the MDM-1 meter.

l. Increase the signal source output level by 20 dB.

m. The MDM-1 meter should read exactly 5 kHz.

5.3.4 METER RANGE CHECKS.

a. Set MDM-1 MOD switch to EXT (OUT) position.

b. Connect differential voltmeter to MDM-1 SCOPE/DIST ANAL jack. Use care in connecting to SCOPE/DIST ANAL jack as a short may damage the MDM-1.

c. Set FM-10 frequency switches to 012.000 MHz, 0-1 kHz control to OUT and 10 MHz switch to IN position. (Set FM-10C frequency switches to 000.0000 MHz, MODE switch to TONE GEN.)

d. Measure and record for reference the dc voltage reading on differential voltmeter.

e. Set FM-10 frequency switches to 012.005. (Set FM-10C to 000.0050.)

f. Measure and record the dc voltage reading on differential voltmeter.

g. Subtract voltage reading in step 5.3.4-d, from that taken in step 5.3.4-f, and multiply the difference by 0.707.

h. Set the differential voltmeter for ac and dial in the result obtained in step 5.3.4-g.

j. Set FM-10 frequency switches to 012.0V0 MHz, 0-1 kHz control to 0 and 10 MHz switch to IN position. (Set FM-10C GENERATOR MODULATION switch to ON (IN) position and MODE switch to GEN MOD CAL position).

k. Set MDM-1 MOD switch to INT/COMB (IN).

l. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null on the differential voltmeter.

m. MDM-1 meter should indicate 5 kHz ±400 Hz in both + and - positions of the DEV switch.

n. Set the MDM-1 INT MOD/AUDIO OUT control fully CCW and set the DEVIATION RANGE switch to 1.8 kHz.

p. Divide the result of step 5.3.4-g, by 3.33 and dial this result on the differential voltmeter.

q. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null the differential voltmeter.

r. The MDM-1 meter should indicate 1.5 kHz ±190 Hz in both + and - positions of the DEV switch.

s. Set FM-10 frequency switches to 012.V00 MHz.

t. Multiply the result of step 5.3.4-g, by 3 and dial this result on the differential voltmeter.

u. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null the differential voltmeter.

v. The MDM-1 meter should indicate 15 kHz ±850 Hz in both + and - positions of the DEV switch.

5.3.5 INTERNAL FREQUENCY MODULATION AND AUDIO OUTPUT CHECKS

a. Verify that 18 kHz minimum may be obtained on the MDM-1 meter by rotating the INT MOD/AUDIO OUT control.

b. Connect AC/DC VTVM to AUDIO OUTPUT jack.

c. Connect a 600 Ω load resistor across the VTVM terminals.

d. Set INT MOD/AUDIO OUT control for maximum output (fully CW).

e. Set MOD switch to EXT (OUT) position.

f. VTVM should indicate 1 V rms minimum.

g. Remove VTVM and replace with frequency counter.

h. Frequency counter should indicate 1 kHz ±50 Hz.

j. Remove frequency counter and replace with distortion analyzer.

k. Measure distortion.

l. Should be 1% maximum distortion.

m. Remove distortion analyzer.

5.3.6 EXTERNAL FREQUENCY MODULATION CHECKS

a. Connect audio oscillator 600 Ω OUTPUT and AC VTVM to the MDM-1 EXT MOD jack with a BNC T connector.

b. Set frequency of audio oscillator to 1 kHz (400 Hz for FM-10C).

c. Set MDM-1 MOD switch to EXT (OUT) position and DEVIATION RANGE switch to 6 kHz.

d. Set FM-10 frequency switches to 012.0V00 MHz. (Set the FM-10C frequency switches to 000.0000 MHz.)

e. Adjust output level of audio oscillator to produce exactly 5 kHz on MDM-1 meter.

f. Note level of audio oscillator on the AC VTVM. Should be 500 mV rms ±20% (100 mV rms ±20% for FM-10C).

5.4 ALIGNMENT AND ADJUSTMENT

NOTE: Remove MDM-1 from mainframe and reconnect to mainframe with extender cable. Refer to Figure 5-1 for test point locations.

5.4.1 IF AMPLIFIER AND DISCRIMINATOR TUNING

a. Connect oscilloscope to the emitter of Q2.

b. Set 10 MHz switch to IN position and frequency switches to 011.975 MHz with 0-1 kHz frequency control to OUT position (for FM-10C, set MODE switch to MEAS, frequency switches to 009.9750, and 0- 100 Hz control to OUT position. Apply 10 MHz time base output from rear panel connector to MEASURE INPUT jack through an RFA-20 attenuator.)

c. Adjust L3 for maximum amplitude on oscilloscope.

d. Set frequency switches to 012.025 MHz. (For FM-10C, set frequency switches to 010.0250 MHz.)

e. Adjust L2 for maximum amplitude on oscilloscope.

f. Set frequency switches to 012.000 MHz. (For FM-10C, set frequency switches to 010.000 MHz.)

g. Adjust L1 for maximum amplitude on oscilloscope.

h. Repeat steps 5.4.1-b, through 5.4.1-g, until no further peaking is obtained.

j. Connect DC VTVM to TP5.

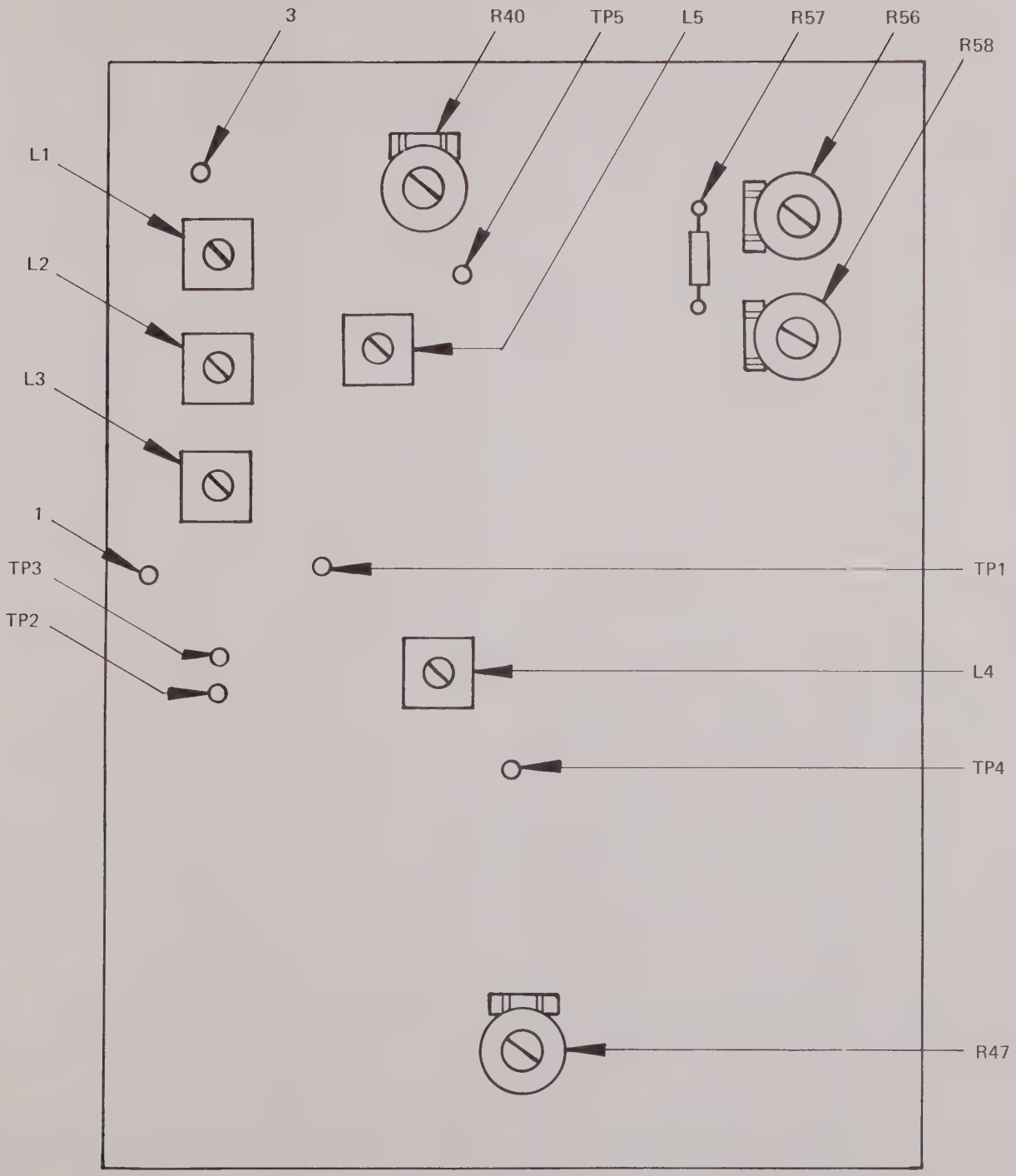

FIGURE 5-1. MDM-1 CIRCUIT BOARD TEST POINT AND TRIMMER LOCATIONS

k. Adjust L5 for maximum dc voltage on the VTVM.

l. Connect oscilloscope with 10X probe to TP3.

m. Adjust L4 so that the "pips" on the waveform are exactly on the peaks of the waveform. See figure 5-2.

FIGURE 5-2 WAVEFORM OF STEP 5.4.1-m

5.4.2 LIMITER CURRENT ADJUSTMENT

a. Connect signal source to FM-10 MEAS INPUT jack and set signal source to 150 MHz at approximately 6 mV rms.

b. Set FM-10 frequency switches to 150.000 MHz and AUDIO switch to BEAT (IN). (Set FM-10C frequency switches to 150.0000 MHz and MODE switch to MEAS.)

c. Tune signal source for zero beat.

d. Set FM-10 frequency switches to 152.000 MHz and AUDIO switch to MOD (OUT). (Set FM-10C GENERATOR MODULATION switch to ON (IN).

e. Connect RF voltmeter with high impedance probe to terminal 3 of PC board.

f. Set signal source level to produce 2.5 mV rms on the RF voltmeter.

g. Adjust R40 for exactly "red line" on the MDM-1 meter.

5.4.3 MODULATION OSCILLATOR ALIGNMENT

a. Connect AC VTVM and frequency counter to AUDIO OUT jack.

b. Connect a 600 Ω resistor across VTVM input.

c. Set INT MOD/AUDIO OUT control fully CW.

d. Adjust R58 for 1.05 V rms on VTVM. If insufficient range on R58, select the value of R57.

e. Adjust R56 for 1 kHz ±10 Hz on frequency counter.

f. Readjust R58 and R56 as necessary.

g. Disconnect AC VTVM and frequency counter.

5.4.4 METER RANGE ADJUSTMENTS AND CHECKS

a. Set MDM-1 MOD switch to EXT (OUT) position.

b. Connect differential voltmeter to MDM-1 SCOPE/DIST ANAL jack. Use care in connecting to SCOPE/DIST ANAL jack as a short may damage the MDM-1.

c. Set FM-10 frequency switches to 012.000 MHz, 0-1 kHz control to OUT and 10 MHz switch to IN position. (Set FM-10C frequency switches to 000.0000 MHz, MODE switch to TONE GEN.).

d. Measure and record for reference the dc voltage reading on differential voltmeter.

e. Set FM-10 frequency switches to 012.005.

f. Measure and record the dc voltage reading on differential voltmeter.

g. Subtract voltage reading in step 5.4.4-d, from that taken in step 5.4.4-f, and multiply the difference by 0.707.

h. Set the differential voltmeter for ac and dial in the result obtained in step 5.4.4-g.

j. Set FM-10 frequency switches to 012.0V0 MHz, 0-1 kHz control to 0 and 10 MHz switch to IN position. (Set FM-10C GENERATOR MODULATION switch to ON (IN) position and MODE switch to GEN MOD CAL position).

k. Set MDM-1 MOD switch to INT/COMB (IN).

j. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null on the differential voltmeter.

m. Adjust R47 for 5 kHz on MDM-1 meter in both + and - positions of the DEV switch.

n. Set the MDM-1 INT MOD/AUDIO OUT control fully CCW and set the DEVIATION RANGE switch to 1.8 kHz.

p. Divide the result of step 5.4.4-g, by 3.33 and dial this result on the differential voltmeter.

q. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null the differential voltmeter.

r. The MDM-1 meter should indicate 1.5 kHz ±190 Hz in both + and - positions of the DEV switch.

s. Set FM-10 frequency switches to 012.V00 MHz.

t. Multiply the result of step 5.4.4-g, by 3 and dial this result on the differential voltmeter.

u. Adjust INT MOD/AUDIO OUT control on the MDM-1 to null the differential voltmeter.

v. The MDM-1 meter should indicate 15 kHz ±850 Hz in both + and - positions of the DEV switch.

5.5 FAULT ISOLATION PROCEDURES

Fault isolation procedures are presented to provide a guide in servicing the MDM-1. The procedures follow the sequence of the Minimum Performance Checkout Procedures, Section 5.3, with each subsection keyed to the paragraph in Section 5.3 that first indicates a fault. When a fault is noted during MDM-1 operation, proceed as follows:

a. Perform minimum performance checkout procedures in section 5.3.

b. Start fault isolation procedures at the point where minimum performance cannot be satisfied.

c. When the fault is isolated to a function, such as the discriminator, refer to the alignment procedure for that function in section 5.4, and check alignment of that function before proceeding with fault isolation.

d. After a fault is repaired, complete the minimum performance checkout procedure to determine if further alignment is necessary.

5.5.1 Sensitivity ("Red Line") is not within Specification (5.3.3-g)

a. Check alignment of 2 MHz active filter, (steps 5.4.1-a through 5.4.1-h).

b. Check alignment of signal threshold circuitry (steps 5.4.2-a through 5.4.2-h).

c. Check MTR switch, S3, circuitry.

5.5.2 Dynamic Range of Meter is Less Than 20 dB (5.3.3-m)

a. Check threshold limiter diodes CR1 through CR6.

5.5.3 6 kHz Range Not Within Specification (5.3.4-m)

a. Check remainder of IF amplifier tuning (steps 5.4.1-h through 5.4.1-m).

b. Check DEVIATION RANGE switch, S1, circuitry; phase splitter, Q6, circuitry; DEV switch, S2 circuitry; recovered audio amplifier, Q7 and Q8; peak detector, U2; and MTR switch, S3, circuitry.

5.5.4 1.8 kHz Range Not Within Specification (5.3.4-r)

a. Check voltage divider network, R16 through R19.

b. Check DEVIATION RANGE switch circuitry.

5.5.5 18 kHz Range Not Within Specification (5.3.4-v)

a. Check voltage divider network, R16 through R19.

b. Check DEVIATION RANGE switch circuitry.

5.5.6 18 kHz Deviation Not Obtained (5.3.5-a)

a. Check modulation oscillator alignment (step 5.4.3-a through 5.4.3-d).

b. Check INT MOD/AUDIO OUT control, R63.

c. Check MOD switch, S4, circuitry.

5.5.7 1 kHz Level Not Within Specification (5.3.5-f)

a. Check EXT MOD jack circuitry.

5.5.8 1 kHz Frequency Not Within Specification (5.3.5-h)

a. Perform steps 5.5.6 and 5.5.7.

5.5.9 1 kHz Distortion Not Within Specification (5.3.5.1)

a. Perform steps 5.5.6 and 5.5.7.

5.5.10 External FM Sensitivity Not Within Specification (5.3.6-f)

a. Check 1 kHz driver amplifier, Q13 and Q14.

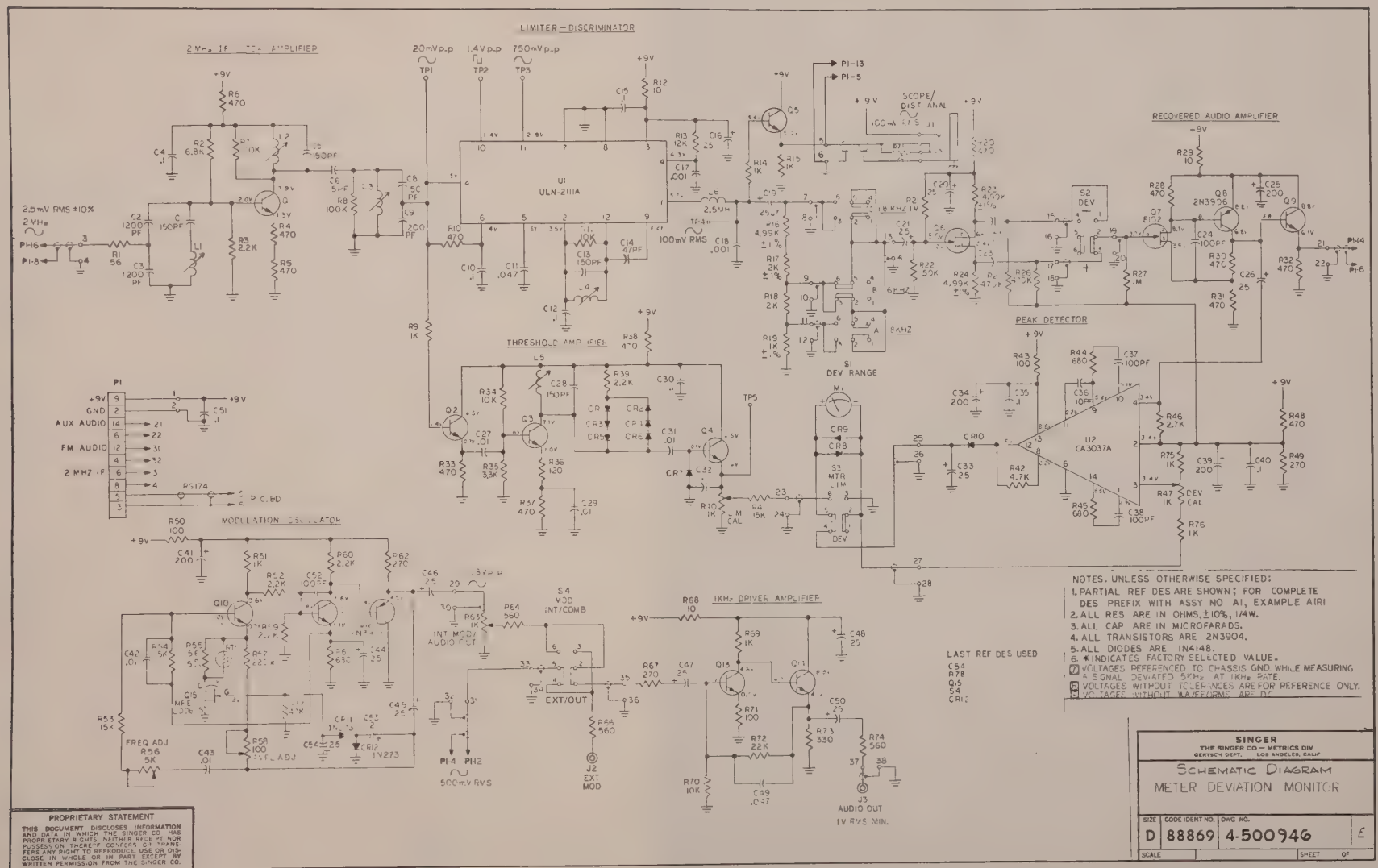

FIGURE 6-1. MDM-1 SCHEMATIC DIAGRAM

SECTION VII

PARTS LIST

TABLE 7-1

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbook H4-2.

CODE NO.	MANUFACTURER	ADDRESS
01121	Allen Bradley Co.	Milwaukee, Wis.
03606	Radio Corp. of America RCA Electronic Prod. Div.	Camden, N. J.
03877	Transitron Electronic Corp.	Wakefield, Mass.
04062	Elmenco Products Co.	New York, N. Y.
04713	Motorola, Inc.	Phoenix, Az.
15801	Fenwal Electronics Inc.	Framingham, Mass.
24446	General Electric Co.	Schenectady, N. Y.
56289	Sprague Electric, Co.	North Adams, Mass.
71450	CTS Corp.	Elkhard, Ind.
73445	Amperex Electronic Co.	Hicksville, N. Y.
75042	International Resistance Co.	Philadelphia, Pa.
76433	General Instrument Corp.	Newark, N. J.
76493	J. W. Miller Co.	Los Angeles, Calif.
88869	Singer Instrumentation	Los Angeles, Calif.
The following vendors have no number assigned in the latest supplement to the Federal Supply Code for Manufacturers.		
0000A	Siliconics	Sunnyvale, Calif.

TABLE 7-2. MODULE DEVIATION METER CHASSIS PARTS

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
CR8	Diode; Silicon	913007-001	03508	1N4148
CR9	Diode; Silicon	913007-001	03508	1N4148
J1	Jack, Telephone	910152-001	82389	S13B
J2	Connector, Receptacle: BNC, Bulkhead Mounted	910043-002	11636	KC93TR5
J3	Connector, Receptacle: BNC, Bulkhead Mounted	910043-002	11636	KC93TR5
M1	Meter: Marked Peak Deviation, 'LIM CUR' Kilohertz, 0-6, 0-18 scale	937008-001	88869	
P1	Connector, Receptacle: 16 Pin, Rectangular Shape	910071-001	02660	26-159-16
R63	Resistor, Variable Composition: 1 Kilohm ±20% 1/2 W	945009-002	71450	45-1K
R64	Resistor, Fixed Composition: 560 ohm ±10% 1/4 W	945000-034	01121	CB5611
R65	Not used			
R66	Resistor, Fixed Composition: 560 ohm ±10% 1/4 W	945000-034	01121	CB5611
R78	Resistor, Fixed Composition: 100 ohm ±10% 1/4 W	945000-025	01121	CB1011
S1	Switch, Push Button: DPDT, 3 Station-interlock	951023-001	88869	
S2	Switch, Push Button: DPDT, 3 Stations, push-push	951025-001	88869	
S3	Part of S2			
S4	Part of S2			

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
C1	Capacitor, fixed, mica, 150 pF, ±5%, 500 V dc	900003-034	04062	DM15-151J
C2	Capacitor, fixed, mica 1200 pF, ±5%, 100 V dc	900003-057	04062	DM15-122J
C3	Capacitor, fixed, mica, 1200 pF, ±5%, 100 V dc	900003-057	04062	DM15-122J
C4	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C5	Capacitor, fixed, mica, 150 pF, ±5%, 500 V dc	900003-034	04062	DM15-151J
C6	Capacitor, fixed, mica, 5 pF, ±10%, 500 V dc	900003-004	04062	DM15-050C
C7	Not used			
C8	Capacitor, fixed, mica, 150 pF, ±5%, 500 V dc	900003-034	04062	DM15-151J
C9	Capacitor, fixed, mica, 1200 pF, ±5%, 100 V dc	900003-057	04062	DM15-122J
C10	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C11	Capacitor, fixed, plastic, .047 µF, ±20%, 250 V dc	900001-009	73445	C280AE, .04 µF
C12	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C13	Capacitor, fixed, mica, 150 pF, ±5%, 500 V dc	900003-034	04062	DM15-151J
C14	Capacitor, fixed, mica, 47 pF, ±5%, 500 V dc	900003-021	04062	DM15-470J
C15	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C16	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C17	Capacitor, fixed, ceramic, .001 µF, +100 -0%, 500 V dc	900012-002	56289	5GA-S50
C18	Capacitor, fixed, ceramic, .001 µF, +100 -0%, 500 V dc	900012-002	56289	5GA-S50
C19	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C20	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C21	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C22	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD (Continued)

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
C23	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C24	Capacitor, fixed, mica, 100 pF, ±5%, 500 V dc	900003-030	04062	DM15-101J
C25	Capacitor, fixed, electrolytic, 200 µF, -10 +75%, 15 V dc	900039-002	76433	984-1733
C26	Capacitor, fixed, electrolytic, 25 µF, -10 +25%, 25 V dc	900039-001	76433	984-2203
C27	Capacitor, fixed, plastic, .01 µF, ±20%, 250 V dc	900001-001	73445	C280AE, .01 µF
C28	Capacitor, fixed, mica, 150 pF, ±5%, 500 V dc	900003-034	04062	DM15-151J
C29	Capacitor, fixed, plastic, .01 µF, ±20%, 250 V dc	900001-001	73445	C280AE, .01 µF
C30	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C31	Capacitor, fixed, plastic, .01 µF, ±20%, 250 V dc	900001-001	73445	C280AE, .01 µF
C32	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C33	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C34	Capacitor, fixed, electrolytic, 200 µF, -10 +75%, 25 V dc	900039-002	76433	984-1733
C35	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C36	Capacitor, fixed, mica, 10 pF, ±5%, 500 V dc	900003-008	04062	DM15-100J
C37	Capacitor, fixed, mica, 100 pF, ±5%, 500 V dc	900003-030	04062	DM15-101J
C38	Capacitor, fixed, mica, 100 pF, ±5%, 500 V dc	900003-030	04062	DM15-101J
C39	Capacitor, fixed, electrolytic, 200 µF, -10 +75%, 15 V dc	900039-002	76433	984-1733
C40	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C41	Capacitor, fixed, electrolytic, 200 µF, -10 +75%, 15 V dc	900039-002	76433	984-1733
C42	Capacitor, fixed, plastic, .01 µF, ±20%, 250 V dc	900001-001	73445	C280AE, .01 µF
C43	Capacitor, fixed, plastic, .01 µF, ±20%, 250 V dc	900001-001	73445	C280AE, .01 µF
C44	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 15 V dc	900039-001	73445	C280AE, .01 µF

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD (Continued)

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
C45	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 15 V dc	900039-001	73445	C280AE, .01 µF
C46	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C47	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C48	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C49	Capacitor, fixed, plastic, .047 µF, ±20%, 250 V dc	900001-009	73445	C280AE, .047 µF
C50	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
C51	Capacitor, fixed, plastic, .1 µF, ±20%, 250 V dc	900001-013	73445	C280AE, .1 µF
C52	Capacitor, fixed, mica, 100 pF, ±5%, 500 V dc	900003-030	04062	DM15-101J
C53	Capacitor, fixed, electrolytic, 2 µF, -10 +75%, 25 V dc	900023-016	56289	TE1201
C54	Capacitor, fixed, electrolytic, 25 µF, -10 +75%, 25 V dc	900039-001	76433	984-2203
CR1	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR2	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR3	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR4	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR5	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR6	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR7	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR8	Not used			
CR9	Not used			
CR10	Diode, silicon, 1N4148	913007-001	24446	1N4148
CR11	Diode, germanium, 1N273	913005-001	03877	1N273
CR12	Diode, germanium, 1N273	913005-001	03877	1N273
L1	Coil, variable, 30 to 60 µH	906006-003	88869	
L2	Coil, variable, 30 to 60 µH	906006-003	88869	
L3	Coil, variable, 30 to 60 µH	906006-003	88869	
L4	Coil, variable, 30 to 60 µH	906006-003	88869	
L5	Coil, variable, 30 to 60 µH	906006-003	88869	

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD (Continued)

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
L6	Coil, fixed, 2.5 µH, ±10%, 50 mA	906002-054	76493	70F253A1
Q1	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q2	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q3	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q4	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q5	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q6	FET, silicon, N-channel, E102	958031-003	0000A	E102
Q7	FET, silicon, N-channel, E102	958031-003	0000A	E102
Q8	Transistor, silicon, PNP, 2N3906	958000-002	04713	2N3906-5
Q9	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q10	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q11	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q12	Transistor, silicon, PNP, 2N3906	958000-002	04713	2N3906-5
Q13	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q14	Transistor, silicon, NPN, 2N3904	958000-001	04713	2N3904-5
Q15	FET, silicon, N-channel, MFE2006	958044-003	04713	MFE2006
R1	Resistor, fixed, comp., 56 Ω, ±10%, 1/4 W	945000-022	01121	CB5601
R2	Resistor, fixed, comp., 6.8 kΩ, +10%, 1/4 W	945000-037	01121	CB6821
R3	Resistor, fixed, comp., 2.2 kΩ, +10%, 1/4 W	945000-041	01121	CB2231
R4	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R5	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R6	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R7	Resistor, fixed, comp., 100 kΩ, ±10%, 1/4 W	945000-061	01121	CB1041
R8	Resistor, fixed, comp., 100 kΩ, ±10%, 1/4 W	945000-061	01121	CB1041
R9	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R10	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R11	Resistor, fixed, comp., 10 kΩ, ±10%, 1/4 W	945000-049	01121	CB1031
R12	Resistor, fixed, comp., 10 Ω, ±10%, 1/4 W	945000-013	01121	CB1001
R13	Resistor, fixed, comp., 12 kΩ, ±10%, 1/4 W	945000-050	01121	CB1235
R14	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R15	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R16	Resistor, fixed, comp., 4.99 kΩ, ±1%, 1/8 W	945016-260	75042	RN60D4990F

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD (Continued)

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
R17	Resistor, fixed, film, 2 kΩ, ±1%, 1/8 W	945016-222	75042	RN60D2001F
R18	Resistor, fixed, film, 2 kΩ, ±1%, 1/8 W	945016-222	75042	RN60D2001F
R19	Resistor, fixed, film, 1 kΩ, ±1%, 1/8 W	945016-193	75042	RN60D1001F
R20	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R21	Resistor, fixed, comp., 1 MΩ, ±10%, 1/4 W	945000-073	01121	CB1051
R22	Resistor, fixed, comp., 150 kΩ, ±10%, 1/4 W	945000-063	01121	CB1054
R23	Resistor, fixed, comp., 4.99 kΩ, ±1%, 1/8 W	945016-260	75042	RN60D4991F
R24	Resistor, fixed, comp., 4.99 kΩ, ±1%, 1/8 W	945016-260	75042	RN60D4991F
R25	Resistor, fixed, comp., 470 kΩ, ±10%, 1/4 W	945000-069	01121	CB4740
R26	Resistor, fixed, comp., 1 MΩ, ±10%, 1/4 W	945000-069	01121	CB4740
R27	Resistor, fixed, comp., 1 MΩ, ±10%, 1/4 W	945000-073	01121	CB1051
R28	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4700
R29	Resistor, fixed, comp., 10 Ω, ±10%, 1/4 W	945000-013	01121	CB1001
R30	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R31	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R32	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R33	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R34	Resistor, fixed, comp., 10 kΩ, ±10%, 1/4 W	945000-049	01121	CB1031
R35	Resistor, fixed, comp., 3.3 kΩ, ±10%, 1/4 W	945000-043	01121	CB3321
R36	Resistor, fixed, comp., 120 Ω, ±10%, 1/4 W	945000-026	01121	CB1211
R37	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R38	Resistor, fixed, comp., 470 Ω, ±10%, 1/4 W	945000-033	01121	CB4711
R39	Resistor, fixed, comp., 2.2 kΩ, ±10%, 1/4 W	945000-041	01121	CB2221
R40	Resistor, variable, comp., 1 kΩ, ±30%, 1/4 W	945010-004	71450	U201
R41	Resistor, fixed, comp., 15 kΩ, ±10%, 1/4 W	945000-051	01121	CB1531
R42	Resistor, fixed, comp., 4.7 kΩ, ±10%, 1/4 W	945000-045	01121	CB4721
R43	Resistor, fixed, comp., 100 Ω, ±10%, 1/4 W	945000-025	01121	CB1011
R44	Resistor, fixed, comp., 680 Ω, ±10%, 1/4 W	945000-035	01121	CB6811
R45	Resistor, fixed, comp., 680 Ω, ±10%, 1/4 W	945000-035	01121	CB6811
R46	Resistor, fixed, comp., 2.7 kΩ, ±10%, 1/4 W	945000-042	01121	CB2721
R47	Resistor, variable, comp., 1 kΩ, ±30%, 1/4 W	945010-004	71450	U201
R48	Resistor, fixed, comp., 470 Ω, ±1%, 1/4 W	945000-033	01121	CB4711

TABLE 7-3. PARTS LIST, PRINTED CIRCUIT BOARD (Continued)

REF DES	DESCRIPTION	SINGER PART NUMBER	MFR. CODE IDENT. NO.	MFR PART NUMBER
R49	Resistor, fixed, comp., 270 Ω, ±10%, 1/4 W	945000-030	01121	CB2711
R50	Resistor, fixed, comp., 100 Ω, ±10%, 1/4 W	945000-025	01121	CB1011
R51	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R52	Resistor, fixed, comp., 2.2 kΩ, ±10%, 1/4 W	945000-041	01121	CB2221
R53	Resistor, fixed, comp., 15 kΩ, ±10%, 1/4 W	945000-051	01121	CB1531
R54	Resistor, fixed, comp., 15 kΩ, ±10%, 1/4 W	945000-051	01121	CB1531
R55	Resistor, fixed, comp., 56 Ω, ±5%, 1/4 W	945000-132	01121	CB5605
R56	Resistor, variable, comp., 5 kΩ, ±30%, 1/4 W	945010-006	71450	U201
R57	Resistor, selected, fixed, comp., 150 Ω, nominal ±10%, 1/4 W	945000-027	01121	CB1511
R58	Resistor, variable, comp., 100 Ω, ±30%,	945010-001	71450	U201
R59	Resistor, fixed, comp., 2.2 kΩ, ±10%, 1/4 W	945000-041	01121	CB2221
R60	Resistor, fixed, comp., 2.2 kΩ, ±10%, 1/4 W	945000-041	01121	CB2221
R61	Resistor, fixed, comp., 680 Ω, ±10%, 1/4 W	945000-035	01121	CB6811
R62	Resistor, fixed, comp., 270 Ω, ±10%, 1/4 W	945000-030	01121	CB2711
R63	Not used			
R64	Not used			
R65	Not used			
R66	Not used			
R67	Resistor, fixed, comp., 270 Ω, ±10%, 1/4 W	945000-030	01121	CB2711
R68	Resistor, fixed, comp., 10 Ω, ±10%, 1/4 W	945000-013	01121	CB1001
R69	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R70	Resistor, fixed, comp., 10 kΩ, ±10%, 1/4 W	945000-049	01121	CB1031
R71	Resistor, fixed, comp., 100 Ω, ±10%, 1/4 W	945000-025	01121	CB1011
R72	Resistor, fixed, comp., 22 kΩ, ±10%, 1/4 W	945000-053	01121	CB2231
R73	Resistor, fixed, comp., 330 Ω, ±10%, 1/4 W	945000-031	01121	CB3311
R74	Resistor, fixed, comp., 560 Ω, ±10%, 1/4 W	945000-034	01121	CB5611
R75	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R75	Resistor, fixed, comp., 1 kΩ, ±10%, 1/4 W	945000-037	01121	CB1021
R77	Resistor, fixed, comp., 47 kΩ, ±10%, 1/4 W	945000-057	01121	CB4731
RT-1	Thermistor, disc, 300 Ω, ±10%	945070-001	15801	KB23J
U1	Integrated Circuit, ULN-2111A	926031-001	56289	ULN-2111A
U2	Integrated Circuit, CA3037A	926033-001	03606	CA3037A